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May, 1932

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THE RELATION OF ORGANIC MATTER TO FRUIT GROWING

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We know that the maintenance of soil organic matter is one of the most fundamental considerations in the practice of growing field crops. Crop rotation, the seeding down of land at systematic intervals, the growing of legumes, the practice of composing, the use of commercial fertilizers, all these have more or less resulted from or are concerned directly or indirectly with this problem of organic matter maintenance.

In the first place until a soil contains an appreciable amount of organic matter it cannot be called a soil, but is only a mass of ground up rock.

It has a tremendous influence on soil texture and therefore on soil tilth and ease of handling. This can be realized from a statement of Sir John Russell when he says that when soils carry from 15 to 20 per cent of organic matter, the distinction between sands, loams and clays disappears.

Organic matter is a storage place for most of the soil nitrogen which it can give up gradually as plants need it through its progressive decomposition. It is further a store house for other food elements than nitrogen. When we apply expensive phosphorus and potassium in commercial fertilizers to soil, the soil humus comes to the rescue because it has the power of absorbing these materials and holding them against leaching away.

Organic matter is a stabilizer of crop production, that is, a soil well supplied with this ingredient maintains a more uniform, less fluctuating level of production and withstands adverse seasonal conditions better.

Then again soils receiving organic manures may carry from three to five per cent more water than similar soils without manure. I venture to say that during the past two dry years orchards on soils high in organic matter have suffered less from drought than those on soils in which organic matter has been neglected.

Bear in his recent book on soil management states that the organic matter of a soil is a byproduct of good crop rotation, and that the organic matter of a soil can be maintained adequately with artificial fertilizers, without manure, providing a proper rotation is maintained and the fertilizers used to increase organic residues.

Thorne, formerly director of the Ohio Station has presented a very inter-

(From Seventy-Sixth Annual Report of the New York State Horticultural Society 1913)

esting viewpoint concerning soil organic matter. He has shown that it is possible to maintain crop yields in rotations for 20-30-40 and even 70 years with commercial fertilizers as well as with manure. He maintains that the addition of organic matter to soil for the sake of its carbonaceous material is unnecessary. He explains this point by saying that the larger root growth which may be obtained by the use of chemicals as well as by manure, furnishes all the organic carbon required for the growth and functioning of soil bacteria. This is partly due to the fact that no distribution of organic matter in soil is so effective as that caused by the growth of plant roots.

Manure therefore must be looked upon as simply a carrier of nitrogen, phosphorus, potassium, calcium and magnesium and preserved accordingly, since the cost of these elements in manure is much less than when purchased in commercial fertilizers.

Thorne further states that the same principles also apply to the use of other organic materials. To plow under clover adds nothing but nitrogen and may be quite expensive if we consider its feeding value and the land rental. The root growth of clover, especially sweet clover, is a remarkable pulverizer of soil and rye used as a catch crop is very good in the same way.

If these statements of Thorne are true are they not intimately concerned with the present practices of soil management in orchards?

Professor Anthony said that he considered that soil organic matter is one of the most important problems at present facing the Pennsylvania fruit grower. In other words, this problem has apparently become acute in parts of Pennsylvania.

In this whole matter of organic matter maintenance in orchard soils there are three fundamental facts which bear on present practices.

1. Cultivating rapidly uses up organic matter in all normal soils.
2. Leaving a soil to itself or laying it down to sod conserves organic matter.
3. Organic matter to be of any value to plants must not be static, but must be constantly changing. That is, a productive soil, and one in which high production is to be maintained, is one in which organic matter is constantly being decomposed and lost, but also one in which these losses are constantly being made good by proportional gains in organic matter.

One author has estimated that a cultivated soil may lose, in 11 years, one third of its nitrogen and one half of its organic matter. Losses of organic matter are always greater from soil already well supplied with it, that is tremendous losses occur from manured soils. The application of lime and mineral fertilizers as well as the application of organic matter itself stimulates soil organisms to greater activity which speeds up the loss of humus. For example it has been found that when wheat straw which contains about 40 per cent of carbon is incorporated into soil some 85 per cent of it is soon lost. Vetch, a legume, on the other hand, loses only about 40 per cent of the amount applied. This point has several practical applications. The value of legumes in green manuring of course is indicated. It has also been found that adding some fertilizer nitrogen to the non-legume manures or even to farm manure high in litter will greatly conserve the organic matter of the manure. At the same time such additional nitrogen will prevent any injurious effects on plants growing on the soil due to a withdrawal of available soil nitrogen which is used by the soil organisms which decompose the manure.

Sir John Russell concludes from results on some of the fertile soils of

Canada, as well as from results in Minnesota and Kansas, that exhaustion of organic matter in soil is not due to crop removal as commonly supposed, but to cultivation.

One might think from what I have said that cultivation is an injurious practice. Such is not the case, however, providing we maintain the equilibrium by additions of organic matter. Cultivation without organic matter maintenance is injurious, however, both to soil and ultimately to plants growing upon it. On the other hand it is a well known fact that soil left to itself gains vegetation and organic matter increases. Russell also cites experimental evidence of this point. Soil which was previously under cultivation, when allowed to run wild for 22 to 24 years, gained nitrogen at the rate of 92 pounds per acre. Land seeded to grass in 1856 more than doubled its nitrogen by 1912.

Since a soil, in doubling its nitrogen, must also double its carbon, organic matter in this soil was therefore also doubled in the same period.

At the present time many orchards are still cultivated, but little provision made for organic matter maintenance. Many orchards have been laid down to sod and nitrogenous fertilizers applied to off-set the nitrogen used up by the growth of the grass. Some workers say that they get no response to fertilizers on grass sod after a few years, and the trees, they say, get sod bound. Many growers on the other hand have had orchards in heavy sod for years and sometimes have had to cut down on the amount of applied nitrogen due to excessive tree growth.

These facts go to show that one general recommendation will not cover all cases when conditions are quite different.

On the other hand the increasing response of cultivated orchards to applications of nitrogen fertilizers indicates that many orchards are becoming low in organic matter which is the source of soil nitrogen.

The grower is interested in this subject of soil organic matter only insofar as it affects the economical production of fruit. It must be admitted that fruit trees are less sensitive to some of these soil conditions than are field crops, and therefore injurious effects do not become apparent nearly so quickly. Stewart thus found in Pennsylvania no measurable injurious effects on trees for some years due to omitting organic matter from his plots, but later such effects did become apparent. Gourley of Ohio omitted organic matter from some of his plots for 10 years without great injury, but after eight or nine years some adverse effects were noted. Anthony has noted these injurious effects of lack of organic matter in Pennsylvania but they became especially marked only after a period of some 15 to 18 years.

On our west coast especially in California the maintenance of soil organic matter is one of the most important problems in fruit growing. Due to higher mean annual temperatures organic matter is lost from their soils very quickly.

The fruit growing industry is by no means a new one. The industry is old enough to begin to feel, perhaps almost unconsciously at first, the effects of this disregard of an important soil factor. Decreasing production in many orchards, the premature decline of older orchards which have done their bit in the past, the greater interest in, and importance of, the soil underdrainage problem, the bad physical condition of many heavy soils, all these indicate that soil organic matter, although not the only cause of these conditions, nevertheless a factor to be reckoned with.

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Now a word as to methods of meeting the problems. I do not know that I have anything especially new to offer. Many growers are in fact very successfully meeting the problems already.

The practice of using farm manure supplemented by nitrogenous fertilizers will undoubtedly successfully meet the issue. This system has a further advantage that when the manure is used as a mulch considerable moisture is conserved. But not all fruit growers can or want to be stock raisers and dairymen.

In this case the statement which I quoted earlier from Thorne is well worth consideration. Thorne stated that soil organic matter could be maintained just as effectively by chemicals as by farm manure, but under certain conditions. These conditions are, first, a good crop rotation and second the use of commercial fertilizers to increase the amount of root growth and therefore the amount of organic residue which becomes finally incorporated with the soil. He considers the almost perfect distribution of roots through a soil and the stimulation of their more extensive growth by fertilizers as the factors which make for successful competition between this system of using only chemicals and that of using farm manure. He further mentions sweet clover roots as a great soil pulverizer. I think these statements furnish us a cue as to a rational procedure for soil organic matter maintenance in orchards. Since it is obvious that the trees themselves must permanently occupy the land, any rotation employed must be a matter of green manuring crops. If the orchard is cultivated each year, the annual crop may be used. It should be seeded early however, certainly by June first otherwise the amount of growth secured especially with the legumes is insufficient to make an annual cover worth while. The prevalent idea that early sown covers rob the trees of moisture is considerably exaggerated. Early in the season while the cover crop is establishing itself, the extra moisture used is small in amount and later on in the season when foliage growth is reaching maturity, less moisture is needed by the tree while at that time also the greater growth of cover crop is shading the ground, and cutting down evaporation from the soil surface.

The other extreme of annual cultivation is the orchard which is left in a permanent sod. If this system is used, care should be used to secure a real sod. This can be done easily in sections where blue grass, timothy and red top come in naturally. In other cases it can be regularly seeded on a well prepared seed bed with attention to soil reaction and fertilization to get the seeding established. A good sod is a conserver of soil organic matter, while a poor thin one is not much better than none at all.

There is some difference of opinion as to the wisdom of keeping orchards in sod over a prolonged period of years. Sod orchards of course have to be supplied with nitrogenous fertilizers. Some say that the grass in time uses up all the nitrogen applied and the trees suffer. Anyone who has been in Mr. Hitching's orchard or in the Champlain Valley cannot quite agree with this statement.

We do know however from results secured on introducing the Hohenheim system of pasture management into this country that blue grass especially, but other grass as well, when given nitrogenous fertilizers may rise in protein content from 12 to 14 percent to as high as 24 or 26 percent and even 30 percent. This is ample proof that grass does take up large amounts of nitrogen when supplied with it, so that there are undoubtedly cases where a heavy sod may rob trees of applied nitrogen in increasing quantities. In such

cases the sod should be broken after several years, cultivated for a season and reseeded. That is, sod and short fallow would constitute the rotation.

This same kind of rotation can be used with other green manuring crops besides the grasses. Sweet clover is undoubtedly one of the best since as Thorne says its root system is a great soil pulverizer and furthermore it will grow well in shaded areas where many other crops fail. Red clover and alfalfa are also good and can be left down for several years at a time. They have one advantage over sweet clover—they do not acquire such large, rank growth the second year. Vetch and soy beans are other legumes which some growers like very much. Some of the non-legumes like buckwheat and millet can also be used.

The best time to build up soil organic matter is while the trees are young. At that time a much better growth of green manure crop can be secured and more moisture is available. However, if older bearing trees are at a sufficient distance apart, which they should be for best production, considerable cover crop can be grown, even if it is confined to a 20 foot strip between the tree rows since, after all, the main bulk of absorbing tree roots are in that area.

Finally a word concerning the use of fertilizers as an aid in producing soil-organic matter.

Nitrogen which is so generally used, at present, in orchards will, of course stimulate the growth of the green manure crop. Most of the orchard fertilizer experiments from Maine to California indicate that nitrogen is the only element whose application can be economically justified. It is only within the last few years that a few workers have found some benefit from phosphorous and potassium in orchards. These elements, however, may be very beneficial in securing an increased growth of green manure crop in the orchard especially on some soils. Phosphorous especially is very necessary in the growth of legumes and might well be used for this purpose, while potassium stimulates root activity and may also be beneficial on some of the lighter soils. In other words, the use of these two elements should be considered at present in connection with soil organic matter supply rather than as a necessary and direct addition for tree growth and fruit production.

Finally let me emphasize one more point. Watch your trees and know what they are doing. The tree itself tells the tale.

* * *

WATCH THE MOUSE

Though mice are not as plentiful as they were, the biologists warn us not to let up on control. If you see mouse burrows in the orchard, better drop a little poison bait in the burrow, here and there. Generally this material will fall down deep enough in the burrow not to cause danger of poisoning to livestock or birds. Don't let the mice build up a large family.

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If you plan to make your own Boreaux spray, write West Virginia Agricultural Experiment Station, Morgantown, West Virginia, for Circular 60, entitled "Instant Bordeaux". The information in this circular is bound to be helpful.

VALUE PER TON OF VARIOUS MULCHING MATERIALS IN TERMS OF NITROGEN, PHOSPHORIC ACID AND POTASH

C. L. BURKHOLDER, *Purdue Agricultural Experiment Station*

	Pounds Nitrogen	Pounds Phosphoric Acid	Pounds Potash	Value per Ton
Wheat Straw	10	3	15	$2.25
Rye Straw	9.33	5.33	16	2.34
Oats Straw	12	4	30	3.44
Alfalfa Hay	47.5	12	44.50	8.90
Clover Hay	41	8	32	7.27
Timothy Hay	20	6	26	4.34
Horse Manure	11.8	5.6	14.6	2.57
Cow Manure	9.7	5.4	9.4	2.00

All of these materials have an added value other than actual plant food when used as mulch in an apple orchard. The organic or humus which they contain effects the solubility of soil minerals, the physical structure of soil granules and the water holding power of the soil. Many successful Indiana growers claim that the greater value of drop fruit from straw mulch trees will alone pay the entire cost and spreading of the straw. Another interesting fact worth considering in the above figures is that, on a basis of plant food only, wheat straw is worth 65 per cent and rye 68 per cent as much as oats straw. On the other hand oats straw decays more rapidly and will need remulching oftener. While this would slightly increase the cost of a mulch system in the case of oats straw, it would also return the plant food to the soil somewhat faster than in the case of rye or wheat.

If a ton of oats straw mulch costs $7.00 it is only fair to remember that a large part of this cost will be gradually returned to the soil in actual plant food which makes the advantages of the mulch in improving the mechanical condition and water holding capacity of the soil cost less than it would at first appear.

Experimental yield results from the use of manure are available because of the wide differences in soils, age and vigor of the trees when manure applications were made. In one experiment (Ohio Exp. Sta. Bul. 301) the annual cash gain for five years was $20.75 per acre while in another orchard for the same period the yearly gain was $110.75 per acre. In work conducted in Pennsylvania it is reported that "in ten similar experiments, the gain from stable manure in both tilled and untilled treatments have averaged 79.3 bushels per acre annually while those from commercial fertilizer averaged 73 bushels".

If mulching material is used heavy enough to choke out the growth of grass there is a still further advantage to the trees. A large amount of early spring applications of nitrogen are caught and consumed by the grass plants. This has been shown to be the case in sod orchards.

For instance in the Laurel Experiment (Purdue Bulletin 315) nitrogen determinations were made April 23 and then part of the trees in each plot were given an application of 4-7-6 fertilizer the following day. On May 15 or 20 days later another nitrogen determination was made.

	Nitrogen per million pounds dry soil, Apr. 23	Nitrogen per million pounds dry soil, May 15
Clean culture and cover crop—(Unfertilized)	13.80	3.9
Same—given application 4-7-6 fertilizer	9.44	18.6
Straw Mulch—(Fertilized)	14.54	27.2
Straw Mulch—(Unfertilized)	11.59	14.0
Grass cut and let lay—(Fertilized)	.24	3.2
Grass cut and let lay—(Unfertilized)	6.60	10.6
Grass cut and mulched, straw added—(Fertilized)	11.78	21.1
Grass cut and mulched, straw added—(Unfertilized)	4.90	2.1
Grass cut and mulched—(Fertilized)	.48	23.2
Grass cut and mulched—(Unfertilized)	.49	3.5

In the Laurel experiments (Purdue Bulletin 315) systems of soil management which gave the best moisture conservation produced the largest trees and the better yields. In this case clean cultivation with cover crop and straw mulch were the best plots. The cost of an application of two bales of straw per year per tree in many sections of Indiana will be less than the cost of a system of clean cultivation and cover crop. In addition, it is well to remember that in the Laurel experiment as well as in many other similar tests a system of clean cultivation and cover crop was not successful when followed year after year from the standpoint of the cover crop. As the fertility and organic matter in the upper layer of soil became depleted and the trees began to take more and more food and moisture, no type of cover crop made a worth while growth. This means that commercial fertilizer or manure or both must be used to produce satisfactory cover crop growth in the small area not heavily shaded by trees. Most mature apple orchards in Indiana are planted so close that the volume of cover crop which can be grown even with the use of manure is negligible.

No one system of soil management is ideal for all orchards. However, growers would do well to make a careful study of the best method of moisture conservation under their own particular conditions. Commercial fertilizers certainly are not moisture conservers. In fact, a large area of leaf surface can be developed during the early part of the growing season and if an adequate water supply is not available in July and August, both tree and fruit suffer to a greater extent than in the case of trees not so heavily fertilized. This has been clearly shown in fertilizer plots in the Experimental Orchard at Mitchell.

From Proceedings of Indiana Horticultural Society—January, 1931

* * *

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